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## LABORATORY WORK NO. 33

### REFRACTOMETRY

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- **PRINCIPLE:** The basis of refractometry is the measuring of refractive index. Any time a light ray moves from one material to another at an angle, it changes direction. This is the principle by which a rainbow is formed. The ratio of the angle of refraction in vacuum versus that in a material of interest is the material's refractive index. It follows the Snell Law:

$$\frac{\sin\alpha}{\sin\beta} = \frac{n_2}{n_1}$$

where  $\alpha$  is the angle of incidence and  $\beta$  is the angle of refraction.

Because the value of the relative index of refraction for air equals 1, we may use the relation:

$$\frac{\sin\alpha}{\sin\beta} = n$$

The angle of refraction is measured by a refractometer. The measurement is based on setting the value of the critical angle. When set into the position of the critical angle, the boundary between light and shadow appears in the eyepiece. We set it up into the intersection of both fibers of the crosshairs. It is possible to read out the value of the critical angle from the way the eyepiece is set. We can also find out the refractive index – the scale is calibrated directly in these values. The refractive index depends on the wavelength of light. We can use it for quantitative analysis because there is a linear relation between the refractive index and the concentration of a substance in a solution. Using the method of calibration curve, we can determine the concentration of unknown samples.

#### TASK N. 1 DETERMINATION OF THE MASS FRACTION AND THE REFRACTIVE INDEX OF AN UNKNOWN SAMPLE OF GLUCOSE

- **CHEMICALS:** solid glucose, distilled water H<sub>2</sub>O, unknown sample
- **AIDS:** Abbe refractometer, beakers, scales, weighing boat, tablespoon, Erlenmeyer flasks, drop glass, 100 ml pycnometer
- **PROCEDURE:** We prepare 5 solutions (100 ml) of glucose with rising mass fraction w(%) (0, 5, 10, 15, and 20 %). We find out the density of these solutions pycnometrically according to the formula



$$\rho = \frac{m_2 - m_1}{V}, \text{ [g/cm}^3\text{]}$$

where  $m_1$  is the mass of the empty pycnometer [g],  $m_2$  is the mass of the full pycnometer [g],  $V$  is the volume of the 100 ml pycnometer [cm<sup>3</sup>].

We construct a graph of the dependence of density on the mass fraction (graph 1). We measure on the refractometer the refractive index  $n$  for each of the solutions. We construct a graph of a dependence of index of refraction  $n$  on the mass fraction  $w$  (graph 2). We find out the density of an unknown sample pycnometrically. Using a refractometer, we find out the index of refraction of an unknown sample and we fill the results of our measurement into the table below.

| Mass fraction $w$ (%) | density g/cm <sup>3</sup> | Index of refraction $n$ | Sugar content % |
|-----------------------|---------------------------|-------------------------|-----------------|
| 0                     |                           |                         |                 |
| 5                     |                           |                         |                 |
| 10                    |                           |                         |                 |
| 15                    |                           |                         |                 |
| 20                    |                           |                         |                 |
| Unknown sample        |                           |                         |                 |

■ **CONCLUSION:**

Determine the mass fraction of an unknown sample using graph 1 and 2. Compare the result with the real mass fraction (given by the teacher), with the measured values and the values found with the help of the graphs. Evaluate how precise the used methods were.

**TASK N. 2 DETERMINATION OF SUGAR CONTENT IN VEGETABLES, FRUIT AND DRINKS**

■ **CHEMICALS:** distilled water, foodstuffs to be researched

■ **AIDS:** manual and Abbe refractometer, drop glass

■ **PROCEDURE:** We squash juice from fruit and vegetables and, using the refractometer, we determine the sugar content and the index of refraction. We write down the determined values into the table.



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- **CONCLUSION:** Compare the sugar content in particular foodstuffs and write the differences in measuring using the Abbe and manual refractometer.

| Foodstuff | Index of refraction n | Sugar content % |             |
|-----------|-----------------------|-----------------|-------------|
|           |                       | Abbe ref.       | manual ref. |
|           |                       |                 |             |
|           |                       |                 |             |
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|           |                       |                 |             |
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## STUDENT'S SHEET No. 33

### REFRACTOMETRY

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#### 1. Translate the words to English:

Vlnová délka  
Hranice  
Úhel dopadu  
Rovnat se  
Úhel zlomu  
Hustota  
Odečíst  
Vlnová délka  
Kalibrační křivka

#### 2. Match the English words with Czech equivalents:

|                    |                   |
|--------------------|-------------------|
| Angle of incidence | hmotnostní zlomek |
| Critical angle     | hranice           |
| Boundary           | refraktometr      |
| Refractive index   | úhel zlomu        |
| Density            | refrakční index   |
| Mass fraction      | úhel dopadu       |
| Refractometer      | hustota           |

#### 3. Explain how you determine the sugar content in vegetables:

#### 4. Find the right word for each definitions:

- The degree of compactness in a substance.  
dentisy                      density                      depth
- An instrument for measuring the refractive index.  
refractometer                      refractometr                      refractometer
- The angle of incidence beyond which rays of light passing through a denser medium to the surface of a less dense medium are no longer refracted but totally reflected.  
crisis angle                      critics angle                      critical angle
- A numerical quantity that is not a whole number  
friction                      fraction                      fraction
- A line which marks the limits of an area; a dividing line.  
boarder                      borders                      boundary



**5. Fill in the missing letters into the words:**

R-FR- - TO- -TE-  
E- - AL  
AN-L- OF IN-I-EN-E  
C-L- -RA-T- -N CU-V-  
W-V-LEN- -H  
RE-R- -TI-N IN-E-

**6. Decide, if the following statements are true or false:**

- |  |   |
|--|---|
| a) A refractometer is used for measuring fraction.                         | F |
| b) Refractometers measure liquids only.                                    | F |
| c) We can measure glucose and sucrose level in fruit with a refractometer. | T |
| d) A pycnometer is used to determine the density of a liquid.              | T |
| e) There are only manual refractometers.                                   | F |